# AY 11 Continuous Process Improvement for Strategic Leaders
# IP #6

**Department of Leadership and Strategy**

***Col PJ McAneny***
***AWC/DA***

***We Produce the Future***

# Plan for the Day

- 1st Hour – Lean/Six Sigma Theory
- 2nd Hour – Continue Lean Six Sigma Theory and Begin Dice Experiment Simulation Set-Up
- 3rd Hour – Continue Dice Experiment Simulation

# Course Design

**This course is organized in 4 parts**:

- History/Current Status
- Culture Change (2 and 3)
- Tools and Techniques (4-7) – Lean / Six Sigma
- Understanding/Applying Transformation Tools of the Trade (8-10)

# Review of Flow and Takt Time Concepts

# Objectives

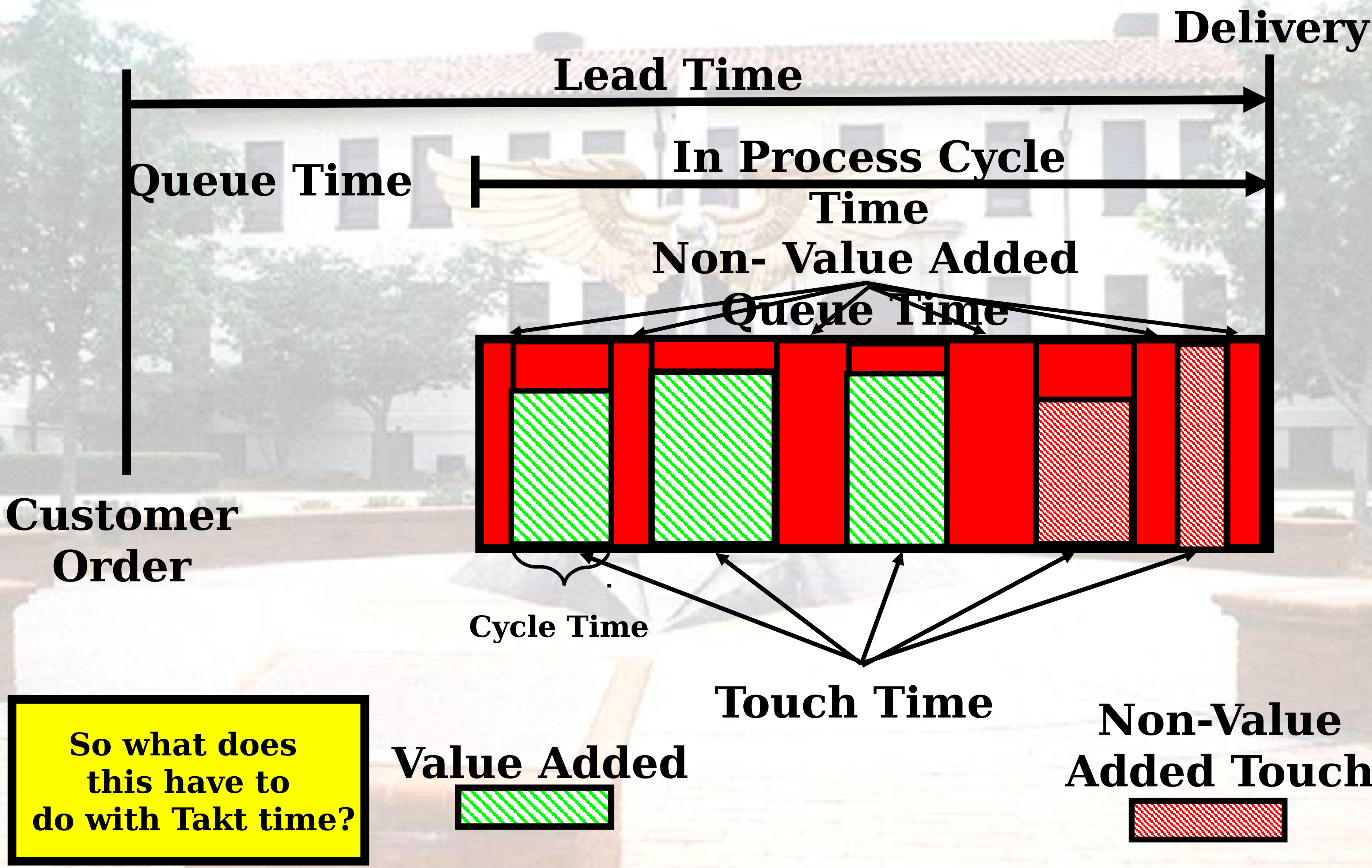


Understanding the following:

- One Piece Flow and speed of delivery,
- Takt Time,
- How all of these concepts assist in understanding and improving a production process

# Categories of Time Review





# Key Understanding



“Slow and steady beats fast and jerky every time” – The Leveling Paradox from The Toyota Way Fieldbook

“Make it flow if you can, pull if you can’t.”

# What is Emphasized on the Factory Floor



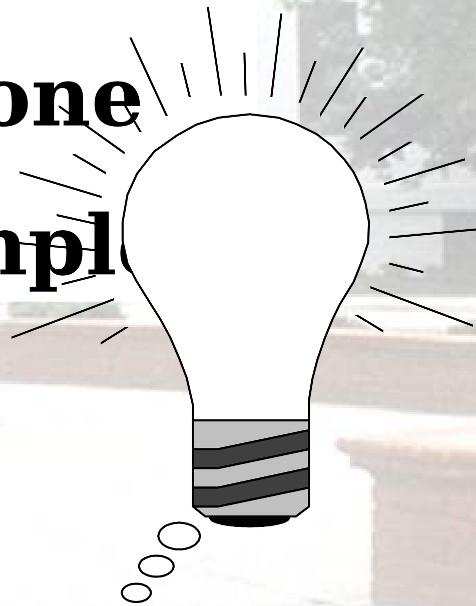
- **<u>Traditional Manufacturing</u>**
  - Keeping people busy

- **<u>World Class Manufacturing</u>**
  - Eliminating delays and waste in product flow
  - Improve the flow of materials

# One Piece Flow



**Let's review a "dot" graphic and explore the impact of one piece flow in a simple example**



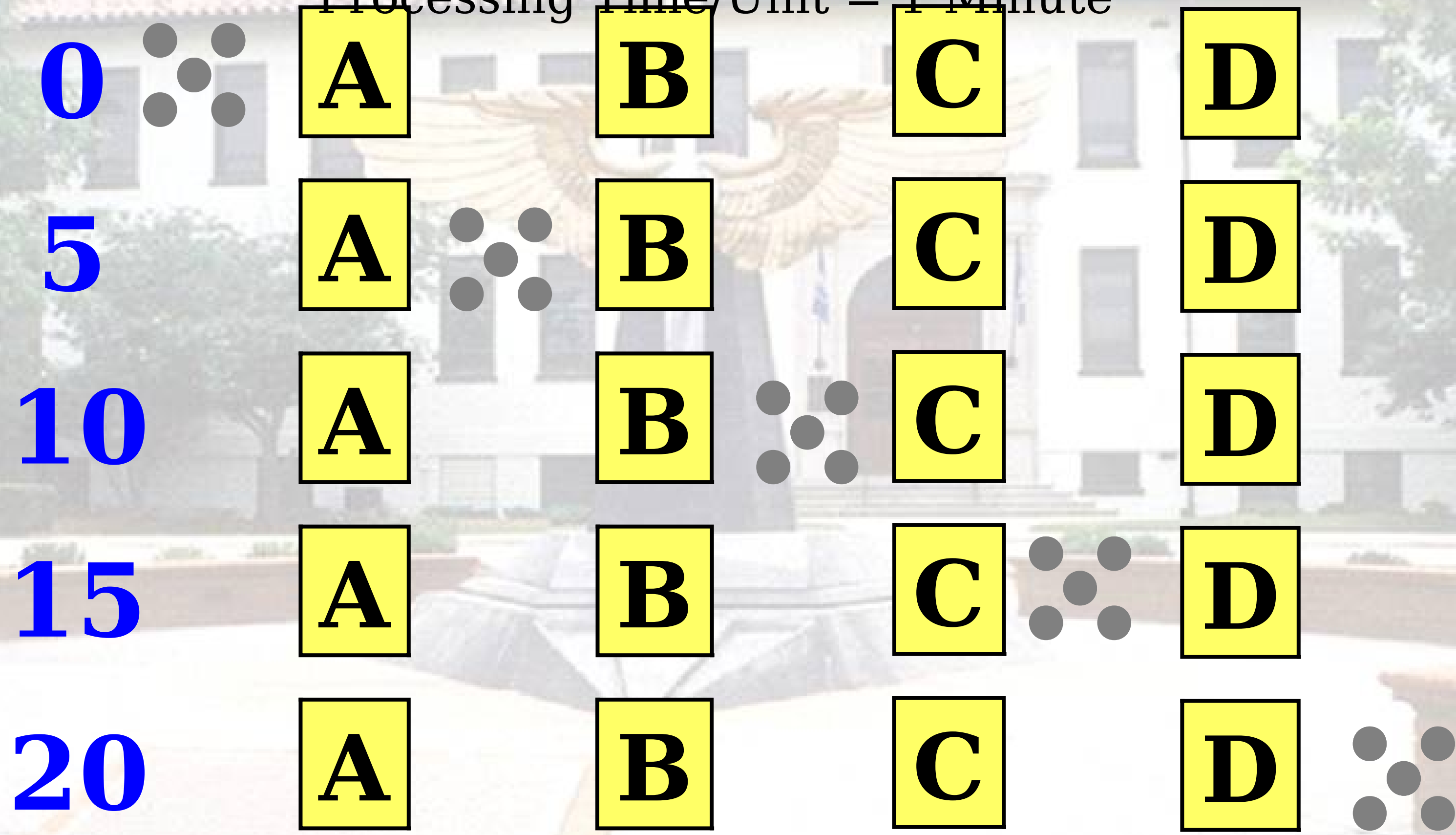
# BATCH vs. ONE PIECE FLOW



**Elapsed Time (min)**

**One Piece Flow with a 5-Piece Batch**

Processing Time/Unit = 1 Minute



# BATCH vs. ONE PIECE FLOW



**Elapsed Time (min)**

**One Piece Flow with a 5-Piece Batch**

Processing Time/Unit = 1 Minute

0 A B C D

***Assuming continuous production, how much Work In Process Inventory would you "normally" have in this cell ???***

20 **A** **B** **C** **D**

***Work In Process (WIP)***

***Finished Goods***

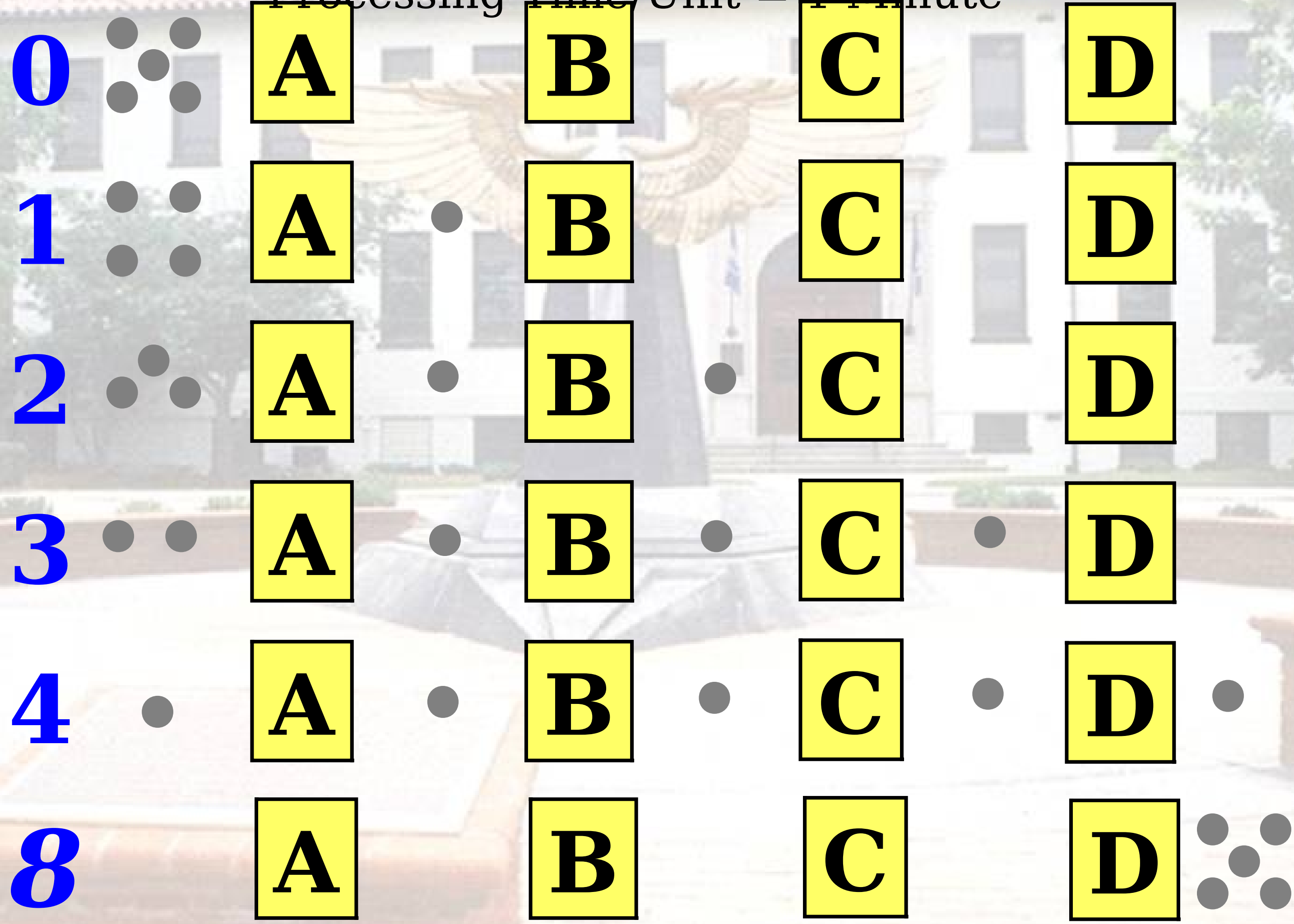
# BATCH vs. ONE PIECE FLOW



**Elapsed Time (min)**

**One Piece Flow with a 1-Piece Batch**

Processing Time/Unit = 1 Minute



**Elapsed Time (min)**

**One Piece Flow with a 1-Piece Batch**

Processing Time/Unit = 1 Minute

| Elapsed Time (min) | | | | |
|---|---|---|---|---|
| 0 | A | B | C | D |
| 4 | A | B | C | D |
| 8 | A | B | C | D |

***And again, how much Work In Process Inventory would you "normally" have in this cell ???***

# BATCH vs. ONE PIECE FLOW



**20 Minutes**

**OR**

**8**

***What would your customer prefer?***

# BATCH vs. ONE PIECE FLOW



# 15 pieces or 3 pieces of WIP

***What would your leadership prefer?***

# Getting to One Piece Flow



- **BATCH SIZE**
  - Reduce Set-Up times and cut lot sizes
  - “Fewer piece flow” - 1 piece is usually better
- **PEOPLE**
  - Multiple Skill Development
  - Multiple Process Handling
- **MATERIALS**
  - Eliminate “Isolated Islands”
- **MACHINES**
  - Laid out in processing order
  - “right” machines to ensure the flow

# One Piece Flow & Standard Work



- Standard work specifies the sequence of tasks assigned to each operator.
- Standard work reduces variation and allows improvements to be sustained.
- It is critical to one piece flow.


17

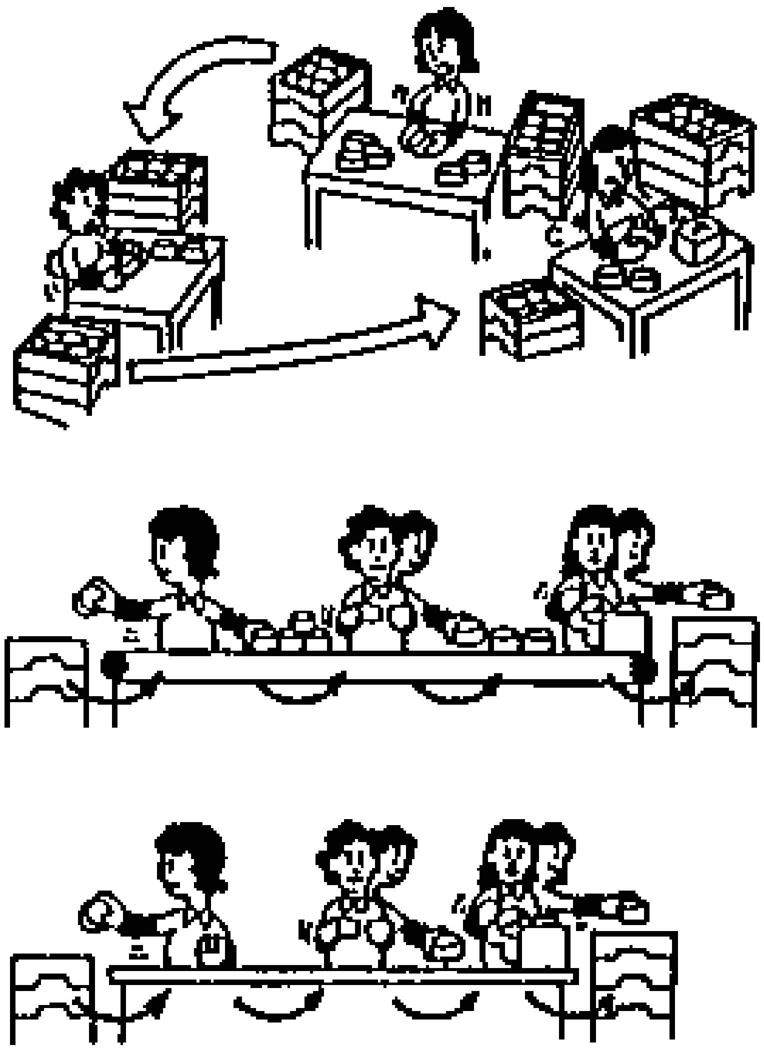
# Developing New Habits

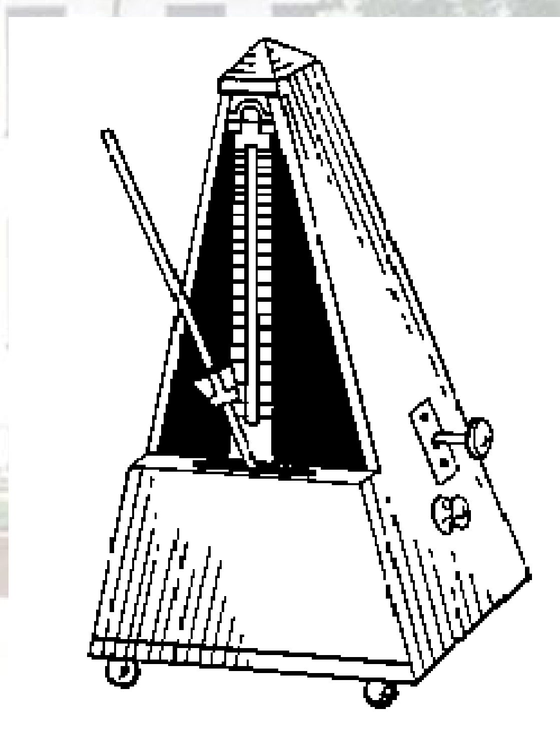


The old habit using Batching

"Wasteful" Flow - it's not easy at the beginning

A habit is developed using 1-Piece Flow





# Takt Time
# What is it ??

# TAKT Time



Takt Time is the time required to produce a component or set of components to meet *customer demand.*

$$\text{TAKT Time} = \frac{\text{Operating Time}}{\text{Customer Requirements}}$$

TAKT Time is subject to change – depending on demand from the customer.

TAKT Time determines rate of production and is key to minimizing manpower.

# TAKT Time Example- Step 1



TAKT Time = $\dfrac{\text{Daily Operating Time}}{\text{Daily Customer Requirements}}$

## ***Daily Operating Time:***

A Day is ***8*** hours long

Convert to minutes ***(8 x 60= 480)***

Subtract two 15 minute breaks ***(480-30= 450)***

Subtract start-up/shut-down time ***(450-15= 435)***

Multiply times number of shifts ***(435x1=435)***

Convert to Seconds ***(435 x 60 = 26,100)***

***→ 26,100 Seconds is the Total Daily Operating Time***

# TAKT Time Example– Step 2



TAKT Time = Daily Operating Time / Daily Customer Requirements

***Total Daily Customer Requirements*** = average daily customer demand.  Assume the average customer demand is 435 units per day.   Therefore, Total Daily Customer Requirements for this part are 435 parts per day.

26,100 available production seconds / ??? parts required per day = ??? Seconds

# TAKT Time Example



TAKT Time = Daily Operating Time / Daily Customer Requirements

***Total Daily Customer Requirements*** = average daily customer demand. Assume the average customer demand is 435 units per day. Therefore, Total Daily Customer Requirements for this part are 435 parts per day.

26,100 available production seconds / 435 parts required per day = 60 Seconds

# Takt Time Calculation Form

*Develop America's Airmen Today ... for Tom*

**Plant Location:** ______________________

**Project Area:** **Date:**

**TAKT Time = total available operating time per day (sec) / adjusted part requirement (qty)**

| **TOTAL AVAILABLE OPERATING TIME (seconds):** | | | **ADJUSTED PART REQUIREMENTS (quantity):** | | |
|---|---|---|---|---|---|
| shift duration | ________ | minutes | customer demand part no. 1 | ________ | pieces |
| - lunch / dinner | ________ | minutes | + customer demand part no. 2 | ________ | pieces |
| - start up | ________ | minutes | + customer demand part no. 3 | ________ | pieces |
| - shut down | ________ | minutes | + customer demand part no. 4 | ________ | pieces |
| - breaks | ________ | minutes | + customer demand part no. 5 | ________ | pieces |
| = net operating time per shift | ________ | minutes | = total customer demand / day | ________ | pieces |
| X number of shifts/day | ________ | shifts | X scrap adjustment factor | ________ | (1+SCRAP%) |
| = net operating time per day | ________ | minutes | **= adjusted no. of parts needed/day** | ________ | **pieces** |
| X seconds/ min | ________ | seconds | | | |
| **= net operating time per day** | ________ | **seconds** | note: average scrap % | ________ | % |

**TAKT Time = total available operating time per day (sec) / adjusted part requirement (qty) = = sec/piece**

# TAKT Time, not Cycle Time



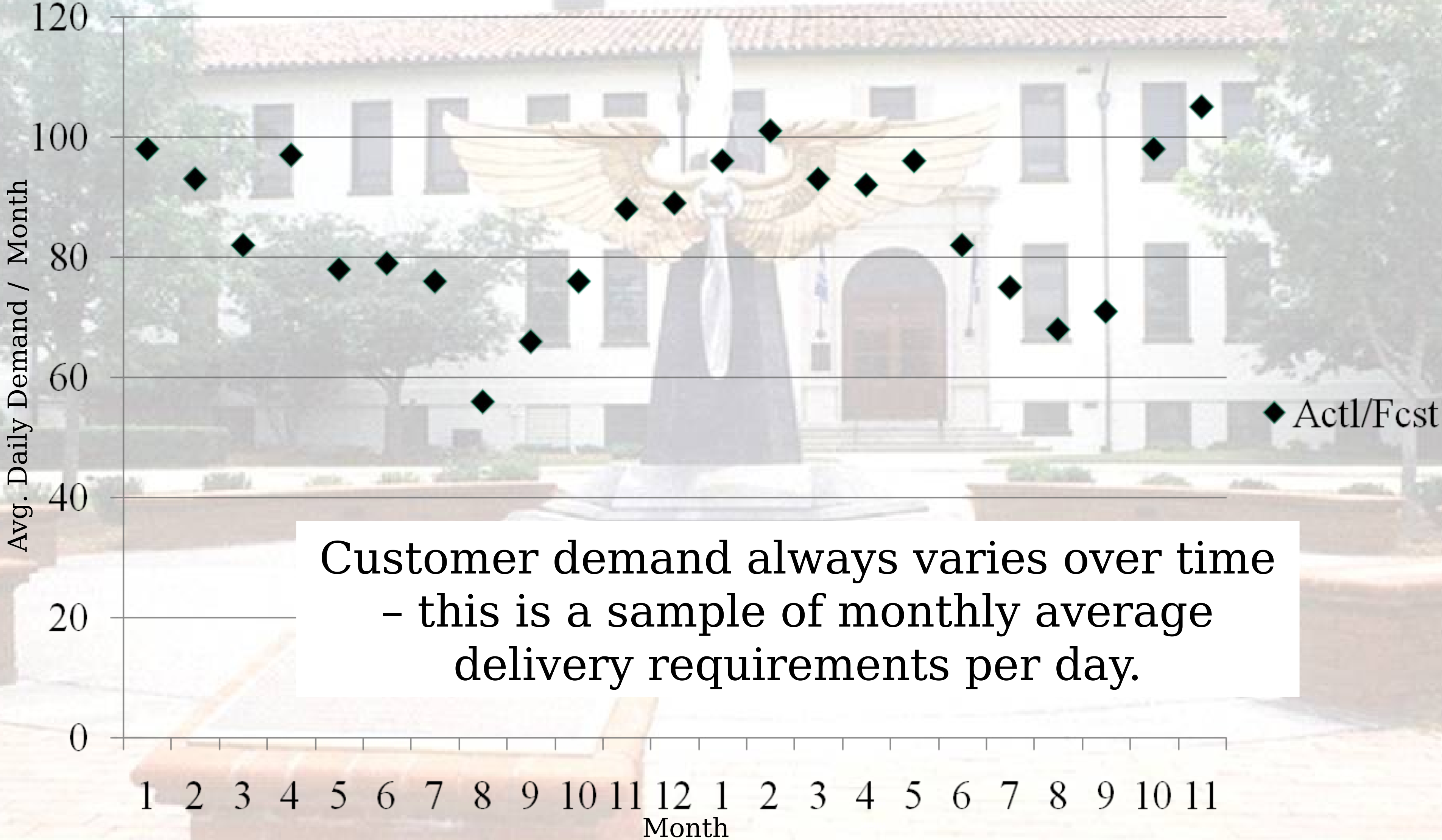
- Cycle time is the time for an operator to do a prescribed task and return to his or her original stance.
- Don’t confuse cycle time and Takt Time !!

*WHAT’S WRONG WITH THIS QUOTE ??*

*“Those people have Takt time down to a science! Their Takt time is 54 seconds. They make a car in 54 seconds and every step in the process takes 54 seconds. And they have a plan to reduce their Takt time to 52 seconds through constantly improving every job! Amazing!!!”*

# Customer Demand Variation

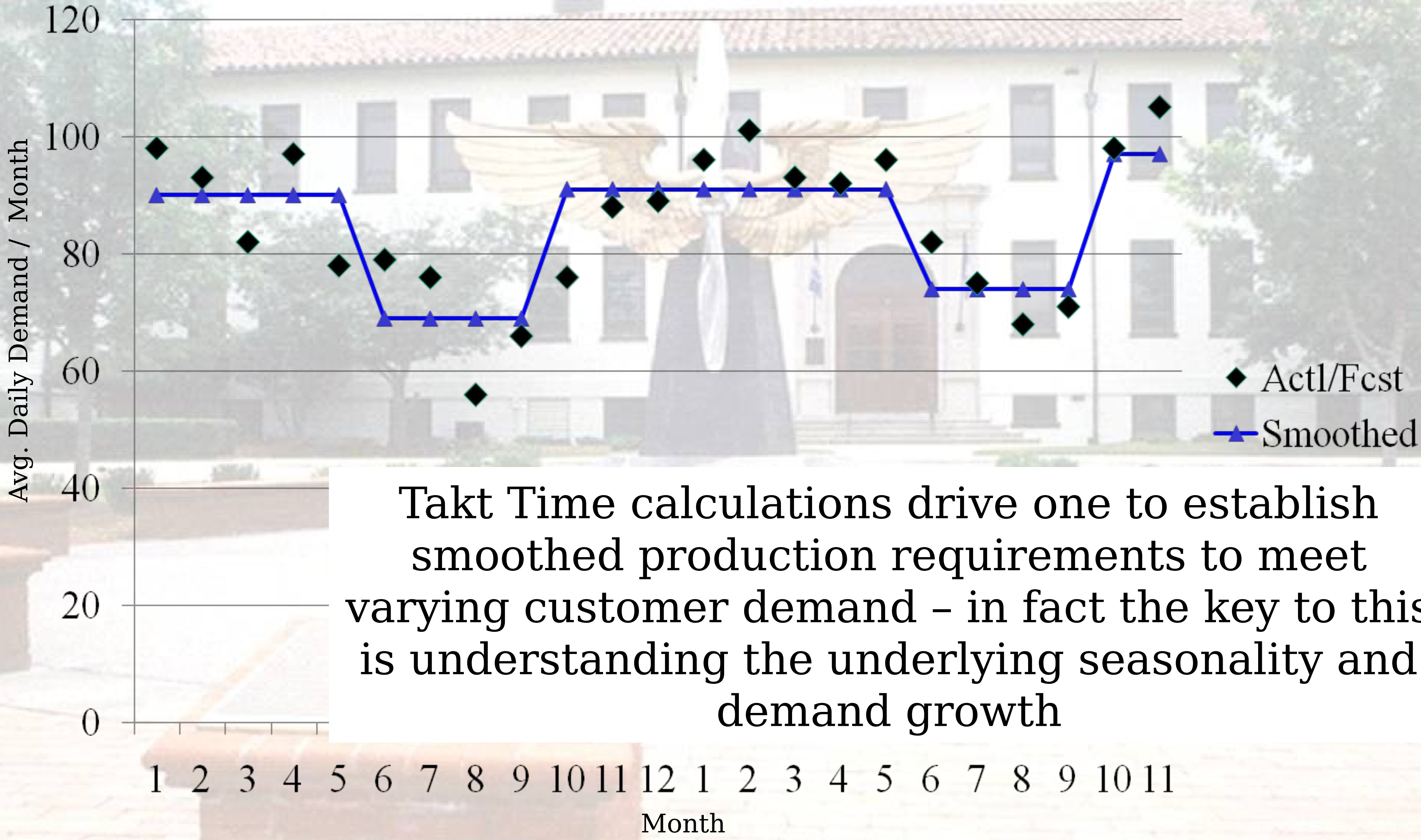




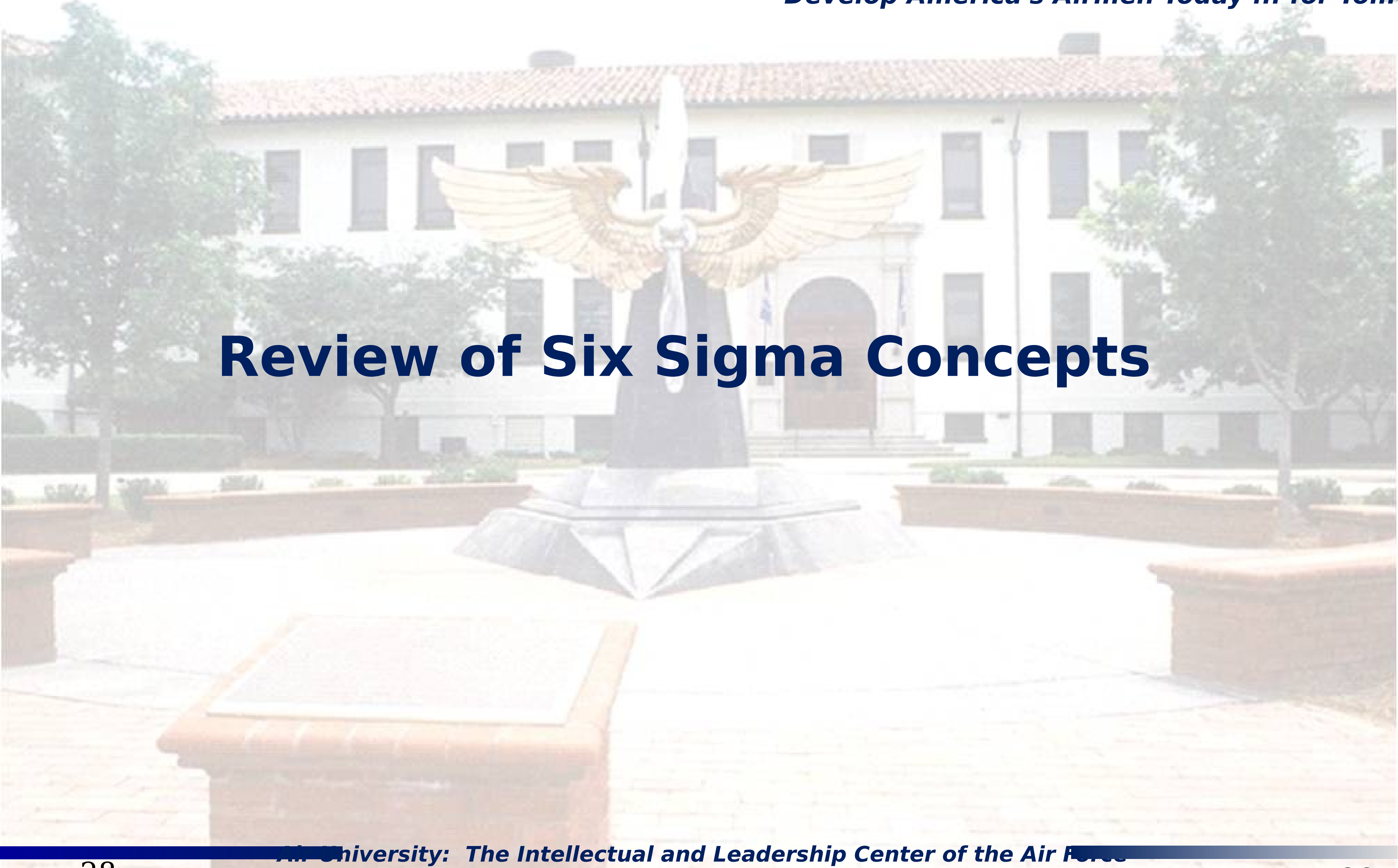

Customer demand always varies over time – this is a sample of monthly average delivery requirements per day.

# Customer Demand Variation and "Smoothed" Production






Takt Time calculations drive one to establish smoothed production requirements to meet varying customer demand – in fact the key to this is understanding the underlying seasonality and demand growth



# Review of Six Sigma Concepts

# Six Sigma Defined



- Sigma is the letter in the Greek alphabet that is used to describe the standard deviation (a measure of variation) of a statistical population
- The goal of Six Sigma is to reduce variation in a process
  - Originated in studies of process capability
- All processes have variation!
  - However, not all variation in the process results in process or customer “defects”
- Six Sigma refers to a process that is in such control that less than 3.4 “defects” occur in every million opportunities
  - The variation in the process is well within customer and process specifications

# Why Mean AND Range

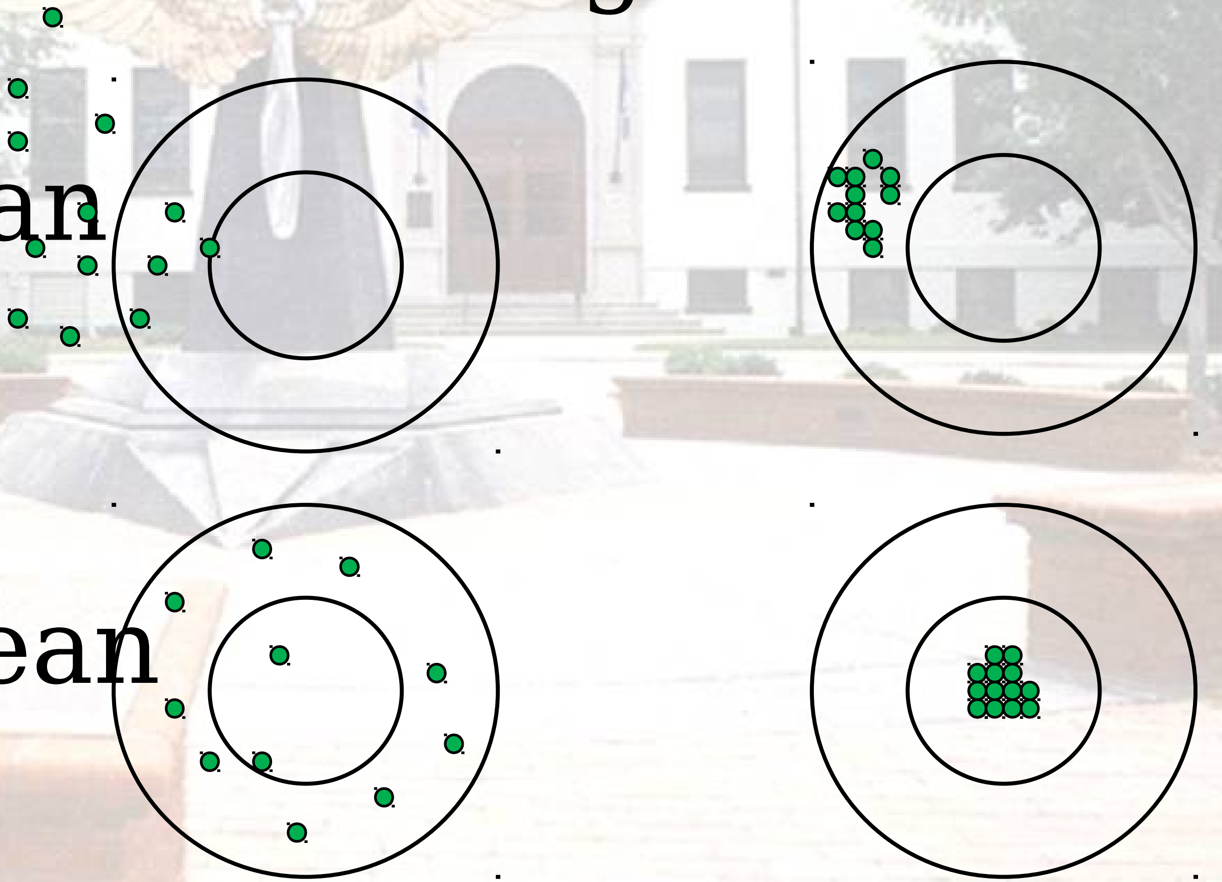
Repeatability

Reproducibility

Poor Range Good Range

Poor Mean

Good Mean



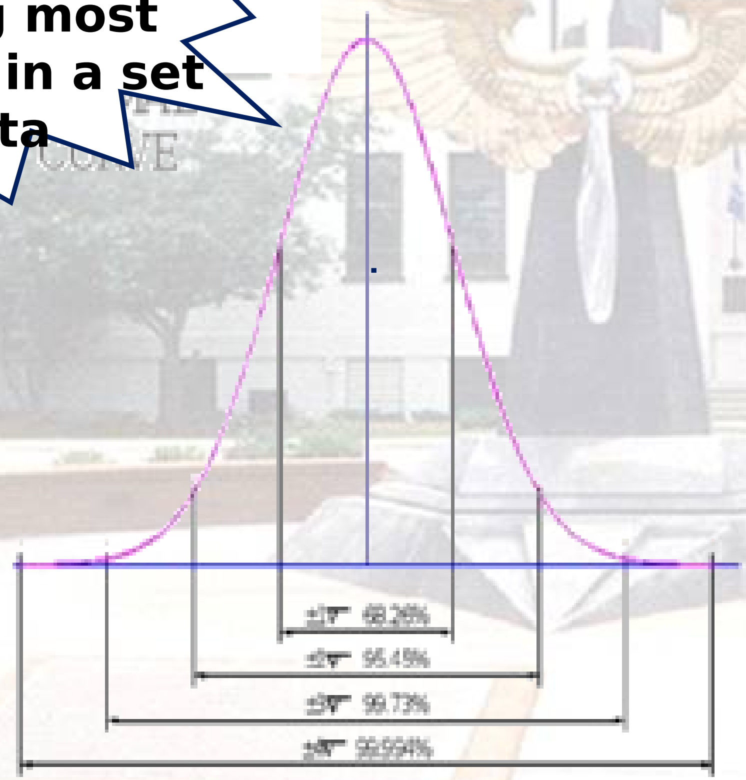

30

# The Normal Curve



**Mode - The value occurring most frequently in a set of data**

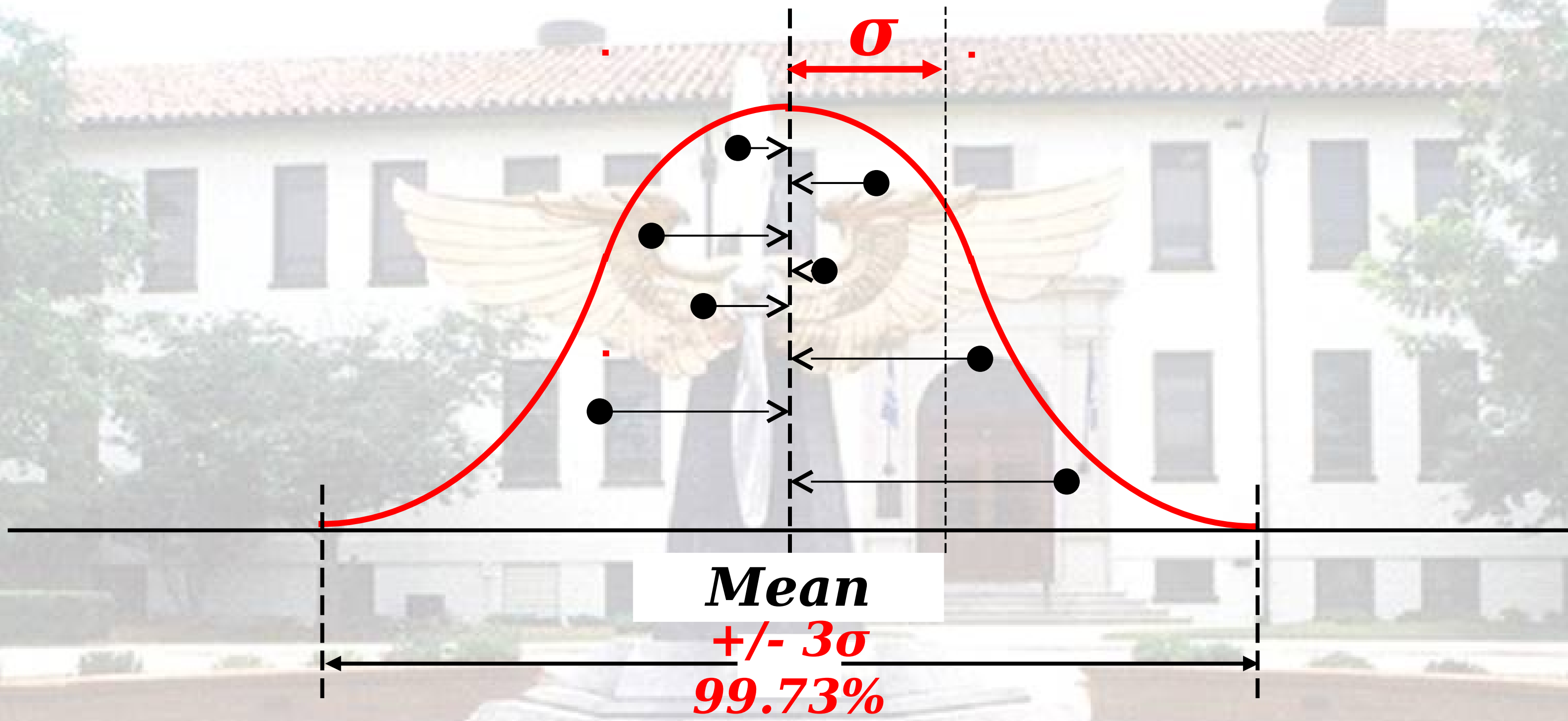
**Median - The 'middle value' when data is arranged in increasing or decreasing order**



Measures - Mean, Mode, Median, Range, Standard deviation

# Standard Deviation






- A more efficient measure of variability
- The average distance of values away from the process mean
- Denoted ***s*** for a sample & ***σ*** for a population

# Calculating Standard Deviation



| Measure (X) | Average (Xbar) | X-Xbar | $(X\text{-}Xbar)^2$ |
|---|---|---|---|
| 50 | | | |
| 55 | | | |
| 54 | | | |
| 51 | | | |
| 55 | | | |
| 53 | | | |
| 53 | | | |
| 54 | | | |
| 52 | | | |

$$\frac{\sum(X-\overline{X})^2}{n-1} = \frac{\qquad}{8}$$

*(n = number of measures)*

$$\sqrt{\frac{\sum(X-\overline{X})^2}{n-1}} =$$

$$\sigma =$$

$$\sum(X-\overline{X})^2 = \underline{\qquad}$$

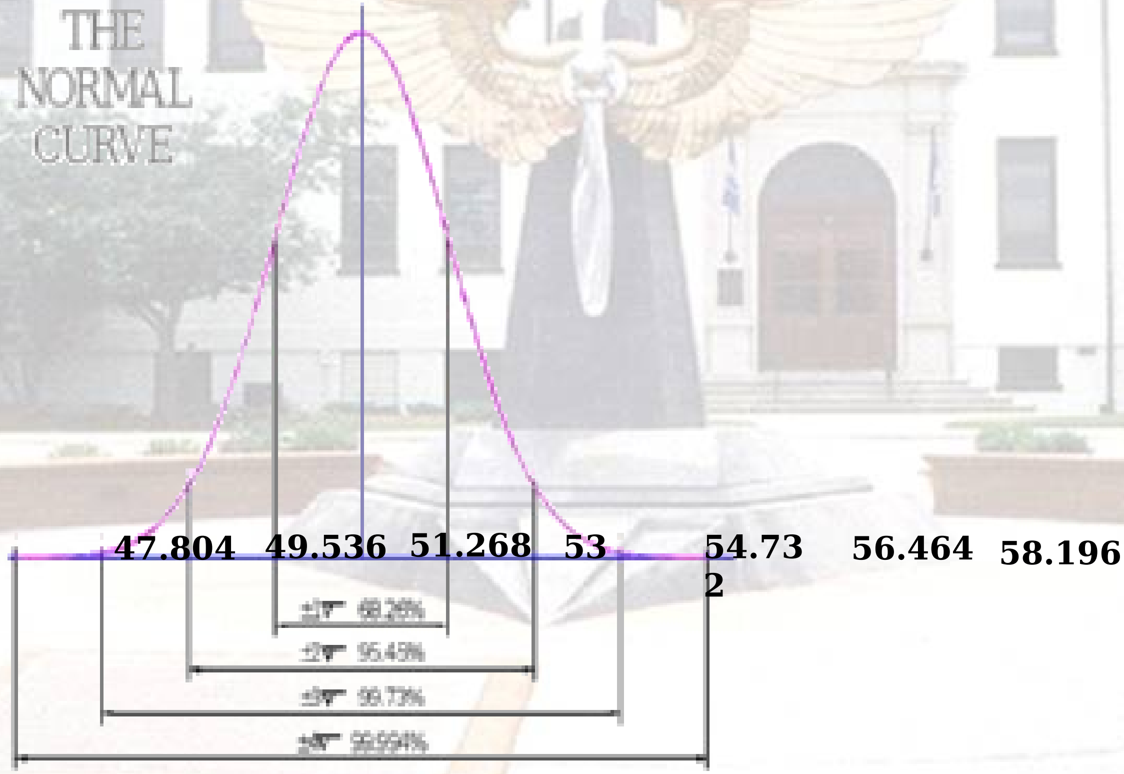

33

# What it means…



- From the previous example, assuming the samples taken were from a normally distributed process:
  - 68% of our measures should fall between +/- 1 sigma (between 51.268 and 54.732)
  - 95% of our measures should fall between +/- 2 sigma (between 49.536 and 56.464)
  - 99.7% of our measures should fall between +/- 3 sigma (between 47.804 and 58.196)
- If the value represented is the average number of pills in a refill that are taken weekly by patients that will be out of country for 12 months, what are the implications?
- If it is the average distance in yards that you hit your new sand wedge, what are the implications?

# The Normal Curve

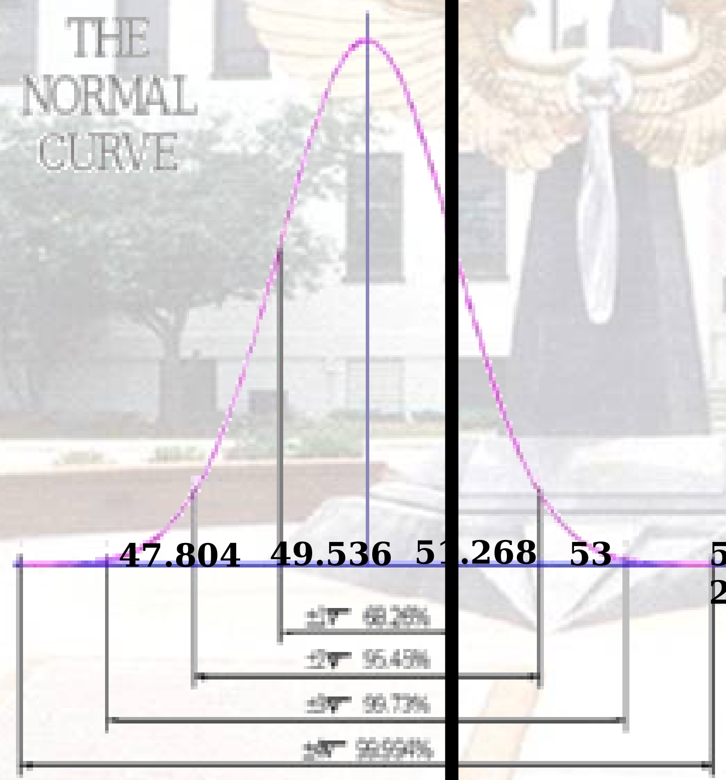


# The Normal Curve



Minimum = 52

Sand Wedge




47.804 49.536 51.268 53 54.732 56.464 58.196

Sand Wedge

Prescription

# Assigned Reading Questions



- According to George, what is the relationship between process, speed, quality, and price?
- What is Deming’s “85/15 Rule”?
- Discuss the key constraint when applying Lean/Six Sigma to “customers” versus “inventory.”


37

# 6σ Key Takeaways



- Sigma is the letter in the Greek alphabet that is used to describe the standard deviation (a measure of variation) of a statistical population
- Six Sigma refers to a process that is in such control that less than 3.4 “defects” occur in every million opportunities
  - The variation in the process is well within customer and process specifications
- The goal of Six Sigma is to reduce variation in a process
  - Originated in studies of process capability
- All processes have variation!
  - However, not all variation in the process results in process or customer “defects”
- If a process has variation (as all do), from a CPI perspective, what are your options?

1. Reduce/Eliminate Variation, or
2. Buffer for Variation
   - With Inventory or With Capacity

- ***The Key is to know when to appropriately apply which!***


38

# Dice Experiment Simulation

# *IP#7*

*Theory of Constraints*

# *The Intellectual and Leadership Center of the Air Force*

***We Produce the Future…***

***One Student at a Time***

***One Faculty Member at a Time***

***One Idea at a Time***

# Backup Slides

# Statistical Process Control (SPC)



- A method to monitor a process to determine whether a change in an important parameter has occurred:
  - Has average value changed?
  - Has level of variation changed?
  - Is the process stable?

- Can be used for tracking and control, plus assessing the capability of a process.

- Can be used to determine if a countermeasure had the desired affect.


43

# Ways to Use SPC



- SPC and periodic process inspection helps to determine whether a process is staying in control or is potentially moving out-of-control at a given point in time.

1. If a process is capable (meeting product specifications) then the  process will be monitored periodically to insure that it remains in control.

2. If the process is not capable, various sub-grouping schemes can be used to determine potential sources of variation and reduce their impact (or eliminate them).

# Common and Special Causes



**Common Causes**

Sources of variation that are small, random fluctuations that act continuously on a process.

**Special Causes**

Produces differences in output from a process that are abnormal and cannot be predicted.


45

# Common and Special Causes

***Variation can be traced back to two types o***

| Common Causes | Special Causes |
|---|---|
| - Many small sources | - One or a few major sourc |
| - Stable | - May be irregular |
| - Relatively predictable | - Unpredictable |
| - Permanent - unless action taken | - May reappear unless acti taken |
| - Inherent causes of variation | - Outside influences |

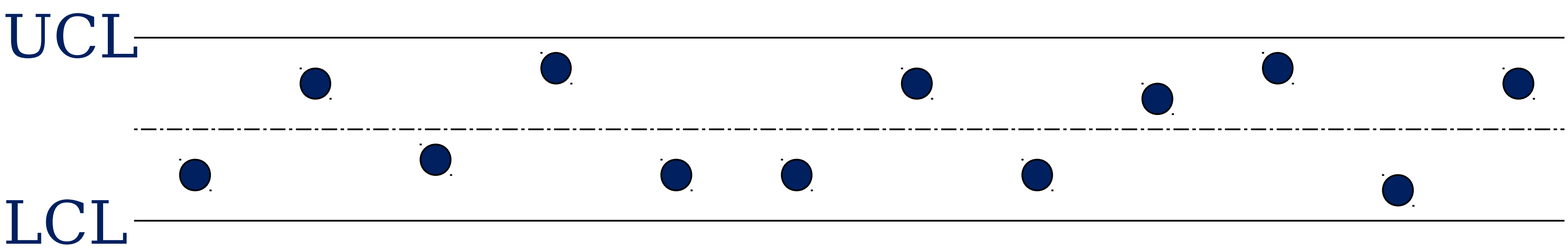
**A process is only in statistical control when source of variation is due to common causes only**


46

# Common Causes



1. Samples are taken from a process over time.
2. Samples are evaluated and average values (and possibly levels of variation) and control limits calculated.
3. All sample values are within the control limits and no runs rules are violated.
4. Process consists of common causes only.
5. Process is said to be in statistical control.





47

# Special Causes



1. Samples are taken from a process over time.
2. Some of the sample values fall outside the control limits.
3. Process consists of common and special causes.
4. Process is said to be out-of-control or unstable.
5. Sources of special causes should be investigated and removed (or limits are not correct).